Data Quality Summary (DQS):

FLASHFlux Version3 TISA (Terra+Aqua)

Investigation:	**FLASHFlux**
Data Product:	**Time Interpolated and Spatially Averaged (TISA)**
Data Sets:	**Terra+Aqua (Instruments: CERES-FM1 or CERES-FM2, CERES FM3, MODIS)**
Data Set Family:	**Version3**
Data Set Versions:	**Version3B**

The Fast Longwave and SHortwave Flux (FLASHFlux) data are a product line of the Clouds and the Earth's Radiant Energy Systems (CERES) project designed for processing and release of top-of-atmosphere (TOA) and surface radiative fluxes within one week of CERES instrument measurement. The CERES project is currently producing world-class climate data products from measurements taken aboard NASA's Terra and Aqua spacecrafts. While of exceptional fidelity, these data products require a considerable amount of processing time to assure quality, verify accuracy, and assess precision. The result is that CERES climate quality data products are typically released more than six months after acquisition of the initial measurements. For climate studies, such delays are of little consequence especially considering the improved quality of the released data products. Since these data products do not require the exacting standards of CERES, the FLASHFlux products were not designed to achieve climate quality. There are, however, many actual and potential uses for the CERES data products on a close to real-time basis. These include CERES instrument calibration and subsystem quality checks, operational usage by related Earth Science satellites, seasonal predictions, land and ocean assimilations, support of field campaigns, outreach programs such as S'COOL, and application projects for agriculture and energy industries.

FLASHFlux data products were envisioned as a resource whereby CERES data could be provided to the community within a week of the initial measurements, with some calibration accuracy requirements relaxed to gain speed. Since the FLASHFlux data were created to provide CERES TOA and surface radiative flux retrievals for the entire globe within one week of measurement, this document provides general information about the data products. Even though FLASHFlux intends to incorporate the latest input data sets and improvements into its algorithms, there are no plans to reprocess the FLASHFlux data products once these modifications are in place. Thus, together with relaxed calibration requirements, the FLASHFlux data products are **not of climate quality**. Users seeking multi-year climate quality data sets should instead use the CERES data products.

The purpose of this document is to inform potential users of the combined Terra and Aqua gridded FLASHFlux data. For most users, the parameters of interest are daily average TOA and surface fluxes. This document also provides potential users with information concerning the differences between various versions of the data products, including the current Version3 family.

This document provides the data users with cautions where they could possibly misinterpret the data; links to further information about the data product, algorithms, and accuracy; and information about planned changes.

The FLASHFlux **Version3** data sets refer to all files within the Version3 family. When changes are made that may noticeably affect one or more output parameters, the letter which follows the version number is changed (e.g., Version5D, Version5E, and Version5F would all belong to the Version5 family of TISA files). All files with the same number belong in the same version family, regardless of the letter that follows. Substantial changes will result in a version number change, which also changes the version family. By definition, adding or removing TISA parameters will always result in a version number/family change. Every TISA version family has its own Data Quality Summary. Note that a change in the input (SSF) version will result in a change to TISA version. Typically, an SSF letter change will result in a TISA letter change and an SSF version number (family) change will result in a TISA version number change. However, the TISA version letter or number may also change independently of the SSF.

The switch from Version2 to Version3 was made to accommodate upgrades due to 1) a new set of calibration coefficients, 2) a new input meteorological data set [GEOS-5 FP-IT (5.9.1)] including Ozone amount, 3) an improved background aerosol [MATCH (Collins et al. 2001) 10 years (Y2000-Y2009) climatology] and 4) numerous upgrades to the surface flux algorithms. The FLASHFlux Version2 family of data sets used a GEOS-5 (5.2) based Meteorological input with SMOBA ozone and WCP-55 broadband aerosol input. For a history of the evolution of Version2 family, the users are referred to FLASHFlux Version2 TISA Data Quality Summary. All of these improvements are presented in tabular form below.

Please note, this document is a high-level summary and represents the minimum information for scientific users of this data product. We strongly urge authors, researchers, and reviewers of research papers to periodically re-check this URL for the latest status of this Data Set Version and particularly before publication of any scientific papers using the data.

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Nature of the TISA Product

The FLASHFlux TISA product is created by combining TOA and surface radiative fluxes derived from CERES Terra and Aqua observations with MODIS-derived cloud properties, temporally interpolated hourly inside a 3-day window and spatially averaged on a 1°x1° grid. FLASHFlux data product will be replaced by CERES SYN1deg product once the latter is available. FLASHFlux typically chooses to process the Terra and Aqua instruments that are in the crosstrack scan mode. To determine the scan mode of CERES instruments on any day of the previous months, the reader is referred to the CERES Operations in Orbit. A complete list of daily and hourly parameters on the TISA is available on the TISA Data Parameters page. Only the daily averaged flux products have been fully validated so far. Efforts are currently underway to validate the hourly averaged flux products, and when completed will be noted in this document.

This Data Quality Summary is written for all TISA files within the Version3 family. When referring to a FLASHFlux data set, please include FLASHFlux, the specific data set version or the data set version family, and the data product. Multiple files that are identical in all aspects of the filename except for the 6 digit configuration code (number to the left of the data date) differ little scientifically. Users are encouraged to read the Cautions and Helpful Hints section below to understand the notation of the configuration code. Thus, users may analyze FLASHFlux data from the same data set version and data product without regard to configuration code. If all the files come from one data set version, refer to the data set using that specific data set version. For example, users working only with Version3A files should refer to "FLASHFlux Version3A TISA." If the files are from numerous data set versions of the same family, then refer to the data set as "FLASHFlux Version3 TISA".

Users should analyze FLASHFlux data sets from different version families separately and should not try to create a timeseries of FLASHFlux parameters using data from different version families.

Daily Average TOA Fluxes and Clouds

FLASHFlux TOA flux retrievals use the latest CERES instrument calibration available. The TOA fluxes and clouds have been diurnally averaged using the ERBE temporal interpolation method based on a constant meteorology at the times of Terra (10:30 LT) or Aqua (13:30 LT) overpass. The constant meteorology used is from GEOS-5 Forward Processing Instrument Team (FP-IT).

The MODIS derived clouds properties are based on algorithms developed by Minnis et al. (2011). The aerosol properties are derived from NCAR Model of Atmospheric Transport and Chemistry (MATCH; Collins et al. 2001) by averaging daily data into monthly climatologies over a ten years period.

Daily Average Surface Fluxes

FLASHFlux core mission is to provide high quality data sets to the community within a week of the satellite measurements. In that effort, FLASHFlux makes use of the SW Model B and LW Model B algorithms to derive surface flux parameters. These models are also named Langley Parameterized SW Algorithm (LPSA) and Langley Parameterized LW Algorithm (LPLA), respectively. Currently, FLASHFlux TISA is the only Level 3 gridded product in the suite of CERES Level 3 gridded products that make use of the LPSA and LPLA. All other level-3 products, namely SSF1deg-lite, SYN1deg, and EBAF are based on a different set of algorithms.

Overview of the Fast Algorithms

SW Model B Algorithm (LPSA)

The Langley Parameterized Shortwave Algorithm (LPSA) described in Gupta et al. (2001) was developed to provide a fast radiative transfer method to derive the Earth's shortwave (SW) surface radiation budget. Both CERES and FLASHFlux projects use this algorithm for deriving instantaneous Single Scanner Footprint (SSF) data products. This algorithm is also used by WCRP/GEWEX Surface Radiation Budget (SRB) project for deriving global surface insolation products. The LPSA consists of physical parameterizations that account for the attenuation of solar radiation in simple terms separately for clear and cloudy atmospheres. Numerous improvements briefly described below have been implemented in LPSA for Version3 processing. The original Rayleigh attenuation formulation in LPSA has been replaced by an improved formulation based on Bodhaine et al. (1999). WCP-55 aerosol properties in LPSA have been replaced by monthly climatological properties based on 10-year monthly averages of MATCH aerosol optical depths. An empirical coefficient used in computing cloud transmission in LPSA has been revised downward from 0.80 to 0.75 based on validation results showing significant overestimation of downward SW fluxes for mostly cloudy and overcast conditions.

LW Model B Algorithm (LPLA)

The Langley Parameterized Longwave Algorithm (LPLA) is a fast parameterization derived from an accurate narrowband radiative transfer model (Gupta 1989; Gupta et al. 1992). The LPLA is used by both CERES and FLASHFlux projects for deriving SSF data products and by WCRP/GEWEX SRB project for deriving global LW fluxes. The LPLA computes downward LW flux (DLF) in terms of an effective emitting temperature of the atmosphere, the column water vapor, the fractional cloud amount, and the cloud-base height for each footprint. The effective emitting temperature and column water vapor are computed from temperature and humidity profiles available from the MOA database. Fractional cloud amount and cloud-base height are available from the CERES cloud subsystem. Recent validation of LPLA products by Kratz et al. (2010) indicated significant overestimation of downward LW fluxes when surface skin temperature greatly exceeded near-surface air temperature. As a result, an improvement has been implemented in LPLA to better handle downward longwave fluxes for very high surface skin temperature conditions that commonly occur over daytime dry/arid regions (Gupta et al., 2010). The most recent improvement to this algorithm implemented for Version3 processing pertains to the correction of the underestimation of downward fluxes in the presence of strong inversions commonly encountered in polar areas.

Data Sets within the Version3 family

Note: Important modifications that have gone into Version3 TISA products are presented below.

Version3A

- A new version of correction coefficients from CERES were incorporated into FLASHFlux processing. Compared to Version 2H, this resulted in small increases of up to 1 Wm^{-2} over some ocean areas and similar decreases over land and snow/ice areas in TOA reflected SW flux. Surface downward SW flux changed in the opposite direction. Increases of up to 2 Wm^{-2} for OLR. Surface downward LW flux changed from 0.7 to 1.2 Wm^{-2} globally with higher changes regionally.
- The latest assimilation product from GMAO, GEOS-5.9.1 (GEOS FP-IT) replaces GEOS-5.2.0 as meteorological input to FLASHFlux processing. GEOS-5.9.1 is produced on 5/16 deg. x 1/4 deg. resolution and at 42 pressure levels.
- An improvement implemented in LPLA remedies the severe underestimation of downward LW fluxes encountered in the presence of steep temperature inversions near the surface that commonly occur over polar areas.
- The original Rayleigh attenuation formulation in LPSA has been replaced by an improved formulation based on Bodhaine et al. (1999).
- WCP-55 aerosol properties in LPSA have been replaced by monthly climatological properties based on 10-year monthly averages of MATCH aerosol optical depths supplemented by single scattering albedo and asymmetry parameter values derived from the OPAC database (Hess et al. 1998).
- SMOBA ozone has been replaced by GEOS-5.9.1 total column ozone.
- An empirical coefficient used in computing cloud transmission in LPSA has been revised downward from 0.80 to 0.75 based on validation results showing significant overestimation of downward SW fluxes for mostly cloudy and overcast conditions.
- Solar constant has been changed from 1365 Wm^{-2} to 1361 Wm^{-2} based on recorded observation of SORCE data (Kopp and Lean 2011).
- Valid data dates: January 1, 2013 - August 14, 2014.

Version3B

- The latest version of correction coefficients from CERES calibrations done in December 2013 were incorporated in Version 3B processing. The use of new correction coefficients caused no change in TOA SW fluxes but about a 1.5 Wm^{-2} increase in TOA LW fluxes.
- The LPSA code was modified to constrain clear-sky surface albedo for each surface type to a pre-determined range when values outside those ranges occurred.
- Valid data dates: August 15, 2014 - Present

Cautions and Helpful Hints

- FLASHFlux only produces data sets for one crosstrack CERES instrument from each satellite. The instrument in crosstrack mode for a satellite may change over time. Instrument operation modes typically change at a monthly boundary and are seldom made in the middle of a month. When a failure or anomaly is detected, the instrument FLASHFlux processes may abruptly switch in the middle of a month.

- Users should note that only the daily averaged flux products have been fully validated. Efforts are currently underway to validate the hourly averaged flux products, and when completed will be noted in this document.

- Users who need to know whether the hour box data was extrapolated, interpolated, or associated with an actual observation should consult the Quality Assurance byte in the Quality Assurance Vgroup. The bit definitions are as follows:

  If actual observation, bit0 == 0:
    - bit1: Was there an Aqua observation?, 0=no, 1=yes
    - bit2: Was an Aqua observation used?, 0=no, 1=yes
    - bit3: Was there a Terra observation?, 0=no, 1=yes
    - bit4: Was a Terra observation used?, 0=no, 1=yes

  If interpolated or extrapolated, bit0 == 1:
    - bit1: Was there an earlier observation?, 0=no, 1=yes
    - bit2: Was there a later observation?, 0=no, 1=yes
    - bit3: Which spacecraft was the earlier observation from?, 0=Aqua, 1=Terra
    - bit4: Which spacecraft was the later observation from?, 0=Aqua, 1=Terra

  It should be noted that in the above situation (bit0 == 1), if bit1=0, then bit3 will not have a meaningful value. Similarly, if bit2=0, then bit4 will not have a meaningful value.

- The Model B surface flux parameters have been validated for the Version3 family of data sets. These surface fluxes are computed for all-sky conditions.

- The nomenclature used to describe the fluxes in the TISA data are as follows: Total = Shortwave + Longwave; Net = Down - Up; and All-sky = Clear-sky + Cloudy-sky. The HDF output files often refer to the All-sky case as Tot-sky or Total-sky, which means Clear-sky + Cloudy-sky, rather than Shortwave + Longwave.

Configuration Code

This section refers only to the configuration code designating the TISA file.

Configuration Code is a six digits number before the data date in a product file name. For example, FLASH_TISA_Terra+Aqua_Version3B_113022.20141103 shows the configuration code to be 113011.

The first digit designates input from GMAO. The next three digits correspond to the instruments (FM1, FM2, FM3, or FM4) used to produce this data. Currently, the value 0 is default until NPP(FM5) is ready to be assimilated. The last 2-digits denote changes made to the software or ancillary data inputs for TISA Gridding and TISA Averaging, respectively.

EXAMPLE:

1) Version3B: GMAO 5.9.1, Terra FM1, Aqua FM3, V3 TISA Grid, V3 TISA Avg.
Configuration Code (CC) : 113022

****2) Version3B: GMAO 5.9.2, Terra FM1, Aqua FM3, V3 TISA Grid, V3 TISA Avg.
Configuration Code (CC) : 213022

****3) Version3B: GMAO 5.9.1, Terra FM1, Aqua FM3, NPP FM5, V3 TISA Grid, V3 TISA Avg.
Configuration Code (CC) : 113522

****4) Version3B: GMAO 5.9.1, Terra FM2, Aqua FM3, V3 TISA Grid, V3 TISA Avg.
Configuration Code (CC): 123022

****: Denotes hypothetical future changes.

If we compare examples 1) and 3) above, there will be no differences in the meteorology. The only change that will be affected is the inclusion of NPP data. However; if we compare examples 1) to 2), the meteorology has changed and that may cause changes in the clouds calculation and fluxes calculation as well. Comparing examples 1) and 4), we can readily see that there has been an instrument change in Terra. This CC designation allows us a quick look at the inputs used to produce the data.

Accuracy and Validation

Validation of the FLASHFlux results is actively being pursued. The accuracy of FLASHFlux results will be documented as they become available. Please see the main FLASHFlux web page for more information.

Future Changes

FLASHFlux will not be able to hold the TISA processing constant. As inputs and algorithms change, the quality of the data product will also change. Minor changes that do not impact the science will be denoted by an increase in the 6-digit configuration code that appears just before the data date. Changes that impact the science enough to be noted will result in a letter change within the data set version. Major changes will result in a change to the data set family.

The following are expected to have an impact on the FLASHFlux TISA products:

1. The FLASHFlux products will be made available via the improved CERES ordering tools that will provide for subsetting, interactive graphics and ascii data retrievals.

2. CERES provides updated Terra and/or Aqua spectral correction coefficients.
3. To capture transient events, we plan to incorporate near real-time MODIS or GEOS FP-IT aerosol optical depths into the LPSA.
4. More advanced versions of the emissivity maps are under development and will use wind speed data over water surfaces, and ASTER and MODIS retrievals over land surfaces.
5. Coincident geostationary satellite data is brought in to improve diurnal sampling process and FLASHFlux-GEO products are derived.
6. Improve the spatial resolution to at least 0.5 X 0.5 degree.

Referencing Data in Journal Articles

The FLASHFlux and CERES Teams have gone to considerable trouble to remove major errors and to verify the quality and accuracy of this data. Please provide a reference to the following papers when you publish scientific results with the CERES data:

Wielicki, B. A., B. R. Barkstrom, E. F. Harrison, R. B. Lee III, G. L. Smith, and J. E. Cooper, 1996: Clouds and the Earth's Radiant Energy System (CERES): An Earth Observing System Experiment, ***Bull. Amer. Meteor. Soc.***, **77**, 853-868.

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Collins, W. D., P. J. Rasch, B. E. Eaton, and B. V. Khattatov, 2001: Simulating Aerosols Using a Chemical Transport Model with Assimilation of Satellite Aerosol Retrievals: Methodology for INDOEX. ***J. Geophys. Res.***, **106**, 7313-7336.

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Gupta, S. K., W. L. Darnell, and A. C. Wilber, 1992: A Parameterization of Longwave Surface Radiation From Satellite Data: Recent Improvements. ***J. Appl. Meteorol.***, **31**, 1361-1367.

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Hess, M., P. Koepke, and I. Schult (1998): Optical Properties of Aerosols and Clouds: The Software package. ***Bull. Amer. Meteor. Soc.***, **79**, 831-844.

Kopp, G., and J. Lean, 2011: A new lower value of total solar irradiance: Evidence and climate significance. ***Geophys. Res. Lett.***, **38**, L01706. doi:10.1175/2009JAMC2246.1.

Kratz, D. P., S. K. Gupta, A. C. Wilber, and V. E. Sothcott, 2010: Validation of the CERES Edition 2B Surface-Only Flux Algorithms, ***J. Appl. Meteor. Climatol.***, **49**, 164-180, doi:10.1175/2009JAMC2246.1.

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Feedback and Questions

For questions or comments on the FLASHFlux Quality Summary, contact the User and Data Services staff at the Atmospheric Science Data Center.
